Survey and Investigation of Usage Status According to the Installation of Underground Fire Extinguisher Boxes in Korea’s Traditional Markets

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Abstract: Currently, traditional markets are structurally vulnerable to fire because of the dense concentration of old wooden buildings with tangled wires, such as aging facilities. Particularly in traditional markets, street vendors are usually disorderly located, and nearby roads are crowded due to illegal parking and vehicles stopping on the driveway. When a fire breaks out, it is difficult for the fire truck to enter, which is necessary to extinguish the fire in the early stages and prevent it from expanding into a large fire. With modernization, the number of fires is on the decline; however, fires in traditional markets continue to increase. According to the analysis of fire statistics from January to November 2023, 49 out of 819 fires in sales facilities were in traditional markets, accounting for 5.98% of fires in sales facilities. This is an increase of about 18 cases and an increase of 2.8% compared to fire statistics of about 3.19%, or 31 out of 972 fires at sales facilities as of 2017. Through these statistics, we can observe that the number of fires in sales facilities has decreased; however, the number of fires in traditional markets has increased. Traditional markets are at high risk of accidents due to the poor management of aging facilities and the lack of safety awareness among merchants. Specifically, in the event of a fire, which is likely to develop into a large fire in a short period due to structural problems, construction of high-density shopping malls, and mass loading of highly flammable goods, raising concerns about safety issues. As these problems have continued, the National Fire Agency has developed an emergency fire extinguisher box that could be buried underground in districts requiring fire prevention reinforcement, such as traditional markets and dosshouses. On January 20, 2018, and on May 2, 2018, ten units were first installed in the Seoul area. In this study, we conducted a survey on the current status of underground fire extinguishing systems boxed in traditional markets to identify the merchants’ perceptions and analyze the operation of underground fire extinguishing systems boxed in the market.

Keywords: Traditional markets; Underground fire extinguishing; Large fire

1. Introduction

1.1 Background and objectives

Areas expected to face significant damage in the event of a fire that a mayor or Do governor designates and manages as areas for reinforcement of fire prevention and safety management are referred to as fire prevention and reinforcement districts. The scope of areas that can be managed as fire prevention and reinforcement districts is defined to include market areas; areas where factories and warehouses are concentrated; areas where wooden buildings are concentrated; areas where dilapidated and substandard buildings are concentrated; areas where facilities for the storage and disposal of hazardous substances are concentrated; areas where factories producing petrochemical products are located; industrial complex defined by law; areas where a firefighting system, a fire extinguishing water supply system, or a passage for firefighting action does not exist; and other areas that are deemed necessary by the head of a fire service agency or station to be designated as fire prevention and reinforcement districts [1-3].

Among the fire prevention and reinforcement districts listed above, traditional markets are structurally vulnerable to fire because they are dilapidated facilities with a dense concentration of old wooden buildings and tangled electrical wires. In particular, traditional markets usually have street vendors who are located throughout the market in a disorderly manner, and nearby roads are congested due to illegally parked and stopped cars. These factors can block...
the entry of fire trucks into the market when a fire breaks out, which can cause a much larger fire due to the failure to extinguish the fire in the early stages. While the number of fires has decreased with modernization, fires in traditional markets continue to increase[4].

An analysis of fire statistics from January to November 2023 revealed that traditional markets accounted for approximately 5.98% of all fires in sales facilities with 49 out of 819 cases[5], which represents an increase of 18 cases and 2.8% as compared to fires in traditional markets accounting for approximately 3.19% of all fires in sales facilities (31 out of 972 cases) in 2017[6]. These statistics demonstrate that the overall number of fires in sale facilities has decreased, but the number of fires in traditional markets has increased.

Traditional markets are at high risk of accidents owing to inadequate management of dilapidated facilities and a lack of safety awareness by merchants. In particular, there is a growing concern about safety issues due to the high likelihood of injuries and property damage from a fire spreading and becoming a large fire within a short time because of the way the markets were built and other structural problems such as densely concentrated stores and large quantities of highly flammable goods found within the market[6-8].

Emergency fire extinguisher systems commonly used for initial fire suppression for fires in traditional markets have the disadvantage of occupying above-ground space, which causes narrowing of passageways. This makes evacuation more difficult, causing increased injuries and casualties. Additionally, freezing during the winter can cause initial fire suppression efforts to fail as water to extinguish the fire cannot be sprayed where it is needed. Therefore, establishing measures to address the vulnerabilities of emergency fire extinguisher systems is necessary, and this includes reducing injuries and property damage caused by fires.

As such problems continued to occur, the National Fire Agency developed an emergency fire extinguisher box that can be buried underground in fire prevention and reinforcement districts, such as traditional markets and dosshouses, after the motel fire in Jongno District on January 20, 2018. Subsequently, the pilot installation of ten units in the Seoul area was completed by May 2, 2018. Following the legal amendment in 2020, the establishment of firefighting infrastructure that can cover the entire market in 2021, and administrative pre-announcement of the partial revision (proposed) of "Fire hydrant box performance certification and product testing technology standards" in August 2022, the term "underground fire extinguisher box" was unified as a new item in the National Fire Agency notice (No. 2023-22) on June 23, 2023, whereby its use in initial fire suppression can be expected from official installation and operation[9].

However, because an underground fire extinguisher box is more than four times more expensive than an emergency fire extinguisher system, installing a large number of underground fire extinguisher boxes is difficult due to the high cost. In fact, when comparing the number of emergency fire extinguisher systems and underground fire extinguisher boxes installed in traditional markets throughout Korea, approximately 12,000 emergency fire extinguisher systems have been installed, whereas fewer than 200 underground fire extinguisher boxes have been installed.

Moreover, the management of underground fire extinguisher boxes was inadequate to hinder identification, and although technical standards have been revised, the exact installation standards were unavailable, causing merchants to be unaware of underground fire extinguisher boxes and they were unable to use them properly even if they were aware. Responses to fires in traditional markets are improving as a result of recent legal amendments and the development of firefighting infrastructure. While the installation of underground fire extinguisher boxes implemented by the National Fire Agency can be viewed as an active effort to respond to fires in traditional markets, difficulties with installation and high prices remain, and studies that examine such lingering issues, along with tangible outcomes, can be expected to contribute to the improvement of the overall level of safety. Accordingly, this study was conducted with the following objectives:

First, visiting traditional markets to determine how much merchants know about underground fire extinguisher boxes and how to use them; second, obtaining exact statistics to identify the trends and firefighting infrastructure operating status in markets and performing statistical analysis using the derived statistical data; and third, analyzing problems in the operation of underground fire extinguisher boxes and presenting improvement measures.
2. Main Body

2.1 Overview of underground fire extinguisher box

The official name of the current version of the product is "underground fire extinguisher box," which has basic dimensions of 1000 (W) × 1000 (L) × 900 (H) on the outside and 800 (W) × 800 (L) × 630 (H) on the inside. The top plate has a static load of 350 kN. The compressive strength of the manhole is 90 Mpa; the opening force of the main cover is 61 N; and the opening force of the secondary cover is 22 N. The main and secondary covers must pass at least 100 rounds of open/close testing. It is a product with performance certified by the Korea Fire Institute (KFI) after verification of a diameter of 25 mm, a length of 50 m, a water pressure of 0.45 Mpa, and a water flow rate of 216 m³/min[10]. The actual installation method for the underground fire extinguisher box[11] is shown in Figure 1. The photos show the burying and finishing processes involved in installing an underground fire extinguisher box in a place inside a traditional market with relatively easy user access, with local waterworks used as the water source.

The actual method of using an underground fire extinguisher box[10] is shown in Figure 2. The photos show the underground fire extinguisher box when not in use and opening it to use the reel hose to spray the area where a fire is burning.
In recognition of the need for new fire hydrant boxes based on fire cases in which the firefighting team could not suppress the fire due to a narrow passageway, such as the motel fire in Jongno District on January 20, 2018, pilot installation of the "underground-buried emergency fire extinguisher system" (tentative name) was completed in five traditional markets in Seoul in 2018. On August 19, 2022, the National Fire Agency made an administrative pre-announcement of the "Proposal to revise fire hydrant box performance certification and product testing technology standards” on underground fire extinguisher boxes. In the proposal, an underground fire extinguisher box was defined as a box that can be buried underground for storing fire extinguishing equipment, such as a fire hose. After going through such testing and operating processes, the National Fire Agency revised the "Fire hydrant box performance certification and product testing technology standards” on June 23, 2023, and as a result, the official operation began with the adoption of the performance certification standards for the product recognized as new firefighting technology[3-11].

To prepare the proposal for the performance certification standards of the underground fire extinguisher box, a product recognized as new firefighting technology, adoption of the technical standards of the underground fire extinguisher box was announced through the "administrative pre-announcement on the (proposed) revision of fire hydrant box performance certification and product testing technology standards” on August 19, 2022[12], which was followed by pilot installation and operation. Then, in June 2023, the technical standards of the fire hydrant box were partially revised in accordance with the National Fire Agency notice (No. 2023-22: "Fire hydrant box performance certification and product testing technology standards”), and the technical standards of the underground fire extinguisher box were added. Accordingly, the definition of "underground fire extinguisher box” that is buried underground for storing fire extinguishing equipment, such as fire hose, was added in "Section 2: Definitions," and regulations regarding the structure, operability, material specifications, clarification of corrosion testing standards, new testing standards, and labeling were newly created in accordance with "Article 3: Structure" and other provisions in articles 3-12.

2.2 Limitations of emergency fire extinguisher systems and the need for an underground fire extinguisher box

In traditional markets, alarm systems, including smart detectors for preventing and detecting fires and above-ground cabinet-type emergency fire extinguisher systems for initial fire suppression, have been installed. However, emergency fire extinguisher systems face problems with fire suppression failure and freezing, and thus, new technology is needed to improve these shortcomings. On January 20, 2018, the motel fire in Jongno District resulted in seven deaths due to failed initial fire suppression attributable to a narrow alleyway and a frozen emergency fire extinguisher system. Based on this case, the Seoul Metropolitan Government determined that new technology is needed to prevent the freezing of fire hydrant boxes and address the problem of clearing traffic passageways, which led to the research and development of new technologies that resulted in the development of an underground fire extinguisher box. In 2020, the National Fire Agency recognized the underground fire extinguisher box as a new technology, and on June 23, 2023, the official name and technical standards of the underground fire extinguisher box were revised through the National Fire Agency notice (No. 2023-22: "Fire hydrant box performance certification and product testing technology standards")[10]. The advantages of and need for underground fire extinguisher boxes are as follows:

First, as the box is buried in the floor of the traditional market, vehicle and foot traffic is more convenient. The commercial rights of the market can be protected by providing space for merchants to sell their goods, and firefighters can enter the area more easily in the event of a fire. At the time of the motel fire in Jongno District, only narrow alleyways were available as passageways for fire trucks and firefighters, while having only a cabinet-type emergency fire extinguisher system made fire suppression impossible. These problems create concerns about the blockage of passageways during a similar fire due to goods being sold and narrow alleyways in traditional markets.

Second, underground burying technology can prevent the freezing of water pipes and fire hoses during winter, which enables the normal operation of fire-extinguishing water to make the initial response to a fire more convenient. Emergency fire extinguisher systems are designed to have fire-extinguishing water come up through pipes, but during winter, water gate valves are turned off to prevent freezing[13,14].

However, fires occur more frequently during winter than any other season, and there is a high level of concern about initial fire suppression efforts failing due to the need to use a T-shape screwdriver to turn on the water gate.
valve and manually open the cabinet. On the other hand, an underground fire extinguisher box is designed to use water from underground water pipes, which eliminates the need to bring water up to ground level. It can be used without being affected by seasons or freezing, as it is unaffected by changes in temperature on the ground. Third, because it operates without power, normal operation during a power outage is also possible. In the event of a fire in a traditional market, all power in the market may be shut off due to a power outage. The underground fire extinguisher box was designed to operate without power, requires less time to open the box and valves, and is ready to spray fire extinguishing water immediately, which facilitates initial fire suppression.

2.3. Usage status of the underground fire extinguisher box and questionnaire survey

A survey of locations where underground fire extinguisher boxes had been installed identified twelve traditional markets in Seoul and Gyeonggi areas: Gwangjang Market, Yeongdeungpo Market, Namdaemun Market, Mangwon Market, Ahyeon Market, Osaek Market, Huam Market, Gyeongdong Market, Jungdong Sarang Market, Incheon Hyeondae Market, Incheon Songhyeon Market, and Incheon Sinpo International Market. Among the twelve markets listed above, four could not be surveyed because of circumstances at the market. The remaining eight markets (Yeongdeungpo Market, Mangwon Market, Ahyeon Market, Osaek Market, Huam Market, Jungdong Sarang Market, Hyeondae Market, and Songhyeon Market) were visited and surveyed. A questionnaire survey was conducted on a total of 318 merchants, and in addition to the survey items, the status of the market and fire extinguishing infrastructure in the market were also investigated with cooperation from volunteer firefighting squads. The purpose of the survey was to determine how much the merchants, as users, are aware of underground fire extinguisher boxes, whether they know how to use them, and the level of awareness about fires in markets. The survey items were as shown in Table 1.

| Survey Item |
|-------------|-----------------|
| 1 | Do You Know What to Do in Case of a Market Fire? |
| 2 | Have You Ever Experienced a Fire in a Market or Seen It Happen? |
| 3 | What Do You Think Are Fire Weak Points in the Market? (Obsolescence, Densification, Insufficient Management, etc.) |
| 4 | Do You Think the Market Is Well Prepared for Fire? |
| 5 | Do You Know About the Underground Fire Extinguisher Box? |
| 6 | Do You Know Where the Underground Fire Extinguisher Box Is Installed? |
| 7 | Do You Know How to Use an Underground Fire Extinguisher Box? |
| 8 | Have You Ever Used an Underground Fire Extinguisher Box? |
| 9 | Preference for the Underground Fire Extinguisher Box and the Emergency Fire Extinguishing Box |

3. Survey Results

3.1 Traditional market survey results

In this study, eight traditional markets were surveyed, and the results revealed that 57.55% of merchants had experienced a fire in a market before, and 55.66% of merchants responded that they were well prepared for a fire in a market. Moreover, among the various fire vulnerabilities in the market identified by the merchants, inadequate management was found to be the biggest problem. Furthermore, 66.67% of merchants were aware of fire response measures. The results also showed that 53.15% of merchants were aware of the existence of an underground fire extinguisher box, 45.19% knew where it was, 21.7% knew how to use it, and 12.26% had actually used it before. Finally, 23.59% of all those surveyed indicated that they preferred the underground fire extinguisher box. Figure 3 shows the distribution of the results.

The statistics above demonstrated that the merchants in the markets surveyed lacked awareness of information about the underground fire extinguisher box and how to use it, while they also lacked experience using the box and did not know where it was installed.
3.2 Identification of problems through the survey of markets

By visiting traditional markets and conducting surveys to investigate the current status, the following problems were identified:

First, the management of underground fire extinguisher boxes is inadequate. In some markets, the paint on the underground fire extinguisher box that was initially installed has been peeled off, as shown in the photo below, and as a result, there is no way for people who do not already know what it is to recognize it as an underground fire extinguisher box. Moreover, some boxes that could not be opened or were difficult to open due to damaged handles. Figure 4 shows the above scene.

Second, as shown in the photos below, some merchants ignored the underground fire extinguisher box and
placed their goods on top of it, while there were other cases in which a customer parked his or her car on top of the underground fire extinguisher box. Such findings can be attributed to the lack of awareness about underground fire extinguisher boxes because fire extinguisher boxes have been officially operating for only a short period. Figure 5 shows the distribution of the results.

Figure 5. An object on an underground fire extinguisher box.

Third, it was difficult to find the exact location of the underground fire extinguisher box due to congestion inside the market. The lack of signs and display panels to indicate the location of the underground fire extinguisher box can increase the risk of failed initial fire suppression due to not being able to locate the underground fire extinguisher box during a fire. This problem applies not only to underground fire extinguisher boxes, but all firefighting infrastructure including emergency fire extinguisher systems. Therefore, installation of display panels, as shown in the photo below, is needed. Figure 6 shows the appearance of the site.

Figure 6. Location display panel.

Fourth, underground fire extinguisher boxes cannot be easily installed because of the large budget required for such installation. Because underground fire extinguisher boxes are designed to use underground water by directly connecting a hose to public waterworks, they require high construction costs for burying the box underground and connecting the hose to public waterworks. Consequently, installation of an underground fire extinguisher box costs 2-3 times more, on average, than installation of an emergency fire extinguisher system. However, because the budget is allocated by the city or provisional government with jurisdiction over the area where the market is located, it is difficult to install an underground fire extinguisher box if the budget is too small or there is no budget available.

4. Conclusions

This study conducted a questionnaire survey to investigate areas of improvement from future maintenance/
management and usage perspectives of a firefighting system that was developed, along with existing studies reporting that it is a very effective firefighting system from the perspectives of the National Fire Agency, public entities, development companies, and users for the initial response to fires in traditional markets, which are vulnerable to fires. The conclusions derived from this study are as follows:

First, although the technical standards of underground fire extinguisher boxes were revised in 2023, laws regarding installation standards and usage have not been properly established. Consequently, there is low awareness about underground fire extinguisher boxes, and their use is limited due to the behaviors of some merchants, such as placing their goods on top of the spot where the underground fire extinguisher box is located. Therefore, education and promotion for merchants and citizens, such as installing signs or display panels similar to those used for outdoor fire extinguishers or apartment fire truck zones, are needed, while legislation and the establishment of technical standards for underground fire extinguisher boxes are also needed.

Second, the survey of eight traditional markets indicated that 57.55% of merchants had experienced a fire before, while 55.66% responded that they were well prepared for a fire in a traditional market. In addition, 66.67% responded that they were aware of fire response measures.

Third, 53.15% were aware of the existence of an underground fire extinguisher box, 45.19% knew where it was, 21.7% knew how to use it, 12.26% had actually used it before, and 23.59% preferred the underground fire extinguisher box.

Fourth, the survey of installed underground fire extinguisher boxes revealed that there is a lack of awareness on the ground due to inadequate management. Moreover, there is a need to improve where the box should be installed, considering how busy and congested traditional markets are.

References